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GASTRIC AND DUODENAL CHANGES PRODUCED IN SALINE SOLUTIONS AS A FUNCTION OF THEIR MOLECULAR CONCENTRATION; THE REGULATORY REFLEX Δ - OF THE PYLORIC SPHINCTER

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GASTRIC AND DUODENAL CHANGES PRODUCED IN SALINE SOLUTIONS AS A FUNCTION OF THEIR MOLECULAR CONCENTRATION; THE REGULATORY REFLEX Δ - OF THE PYLORIC SPHINCTER

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ABSTRACT. Studies on the changes suffered in stomach and duodenum by isotonic, hypotonic, and hypertonic NaCl solutions in dependence on their molecular concentration, as well as the functioning of the pyloric sphincter in the presence of such solutions, are discussed. Experiments with aspiration of gastric juice and removal of duodenal juice through a fistula showed that isotonic solutions pass rapidly through the pylorus without undergoing major changes; hypotonic solutions are evacuated less rapidly and show greater changes the farther they are from isotony; hypertonic solutions produce excessive delay of gastric evacuation in proportion with the concentration. Apparently, the more strongly hypertonic the absorbed solution, the more will its pyloric evacuation be retarded. Various values for the regulatory reflex Δ of the pyloric sphincter are determined and listed.

We carried out studies on the osmotic and chemical changes in the stomach and duodenum, suffered by various saline solutions as a function of their molecular concentration, as well as studies on the functioning of the pyloric sphincter in the presence of such solutions.

The technique used in the experiments consisted in a series comparison, at regular intervals, of the gastric juice removed by esophageal probe with the duodenal juice collected directly through a fistula.

The duodenal fistula was made in two steps: First the portion of the /174
duodenum subjacent to the Vater ampulla is attached to the right dorsal wall to which it is anatomically contiguous. A puncture, made several days later at the level of the adhesions, permits a direct introduction into the duodenum of a small-caliber glass probe which aspires the duodenal juice as soon as formed. After removing the probe, the fistula closes spontaneously because of its small dimensions and its dorsal location, without necessitating any mechanical occlusion and without leaving any permanent seepage. Re-introduction of the probe is rather easy and can be repeated indefinitely. With this method, we have kept alive and in excellent health for four months a dog in which we temporarily re-established the fistula about every two days. This method has the advantage of approaching normal conditions since integrity of the digestive tract is maintained.

* Numbers in the margin indicate pagination in the foreign text.

The observed phenomena differ depending on whether the NaCl solutions - the only ones to be discussed here - have a molecular concentration equal to, lower than, or higher than that of the humors of the organism.

The isotonic solutions pass rapidly through the pylorus without undergoing noticeable changes; immediately after introduction of the liquid into the stomach, the pyloric sphincter opens abruptly for a very short time and in close succession, with each opening projecting a wave of liquid into the duodenum and into the cannula. From the very first minute, a series of ejaculation of fluid is observed, corresponding to the series of pyloric openings. In addition, the gastric juice passes rapidly into the duodenum; in one experiment, the introduction of 200 cc of a 7‰ NaCl solution into the stomach resulted in the elimination of 106 cc through the duodenal fistula during the first minutes and of 62 cc during the next five minutes, without noticeable changes in osmotic pressure or in chlorine content.

The hypertonic solutions are evacuated less rapidly and undergo more extensive changes the farther away they are from isotony. Whereas, already with weakly hypotonic solutions (for example, 5/1000 solution), a less rapid and shorter pyloric evacuation is observed than with a 7‰ solution, the phenomenon becomes even more pronounced with strongly hypotonic solutions and, specifically, with distilled water. In this case, the jets of fluid ejection are less frequent and the pylorus opens less often. Gastric evacuation is retarded and protracted; nevertheless, it proceeds with relative rapidity. The changes in molecular concentration take place to a small extent in the stomach and to a /175 larger extent in the duodenum. In fact, immediately after gastric ingestion, a rather abundant secretion of bile and pancreatic juice is observed, which tints the fluid yellow and enables it to digest albumin. This addition has the result of distinctly increasing the molecular concentration and the chlorine content of the duodenal juice. The biliary secretion either continues during the entire duration of the duodenal passage or takes place only at the beginning and at the end. The significance of this finding lies in the fact that no similar phenomenon was ever observed with hypertonic solutions.

To define the respective significance of the stomach and the duodenum in establishing molecular equilibrium with the body fluids, we will give a few data obtained in an experiment in which 200 cc distilled water had been introduced into the stomach; the Δ of the liquid aspired from the stomach which originally had a value of 0° became -0.04° after 5 min and -0.18° after 30 min; the chlorine content which was zero at the beginning became 0.028% after 5 min and 0.145% after 30 min. Conversely, the Δ of the duodenal juice evacuated through the fistula successively became -0.28°, -0.18°, -0.15°, 0.22°, -0.30° with the chlorine content being 0.124%, 0.113%, 0.0958%, 0.138%, 0.216%. The variations in these figures follow the variations in color and are mainly due to the addition of bile to the various fluids.

Summarily, hypotonic solutions are evacuated with a certain delay and undergo a change in the sense of isotony without, however, ever reaching it completely. Apparently, the organism has some difficulty to supersaturate a noticeable amount of fluids with salts, even with the aid of biliary and pancreatic secretions; it might also be that the intestine tolerates the slight difference in concentration observed in hypotonic liquids, which facilitates their absorption.

Hypertonic solutions exhibit much more pronounced phenomena: The gastric evacuation is delayed further and prolonged in proportion to the concentration of these solutions; their osmotic equilibrium with the body fluids is established more readily and more rapidly.

Weakly hypertonic solutions have an action close to that of isotonic solutions: The pyloric evacuation is slightly delayed and prolonged; the liquid is diluted in the stomach and in the duodenum, with its concentration approaching isotony. With a 20‰ solution, the pyloric evacuation starts only after 8 min, proceeds very slowly, and takes 45 min; the Δ drops successively from -1.44° to -1.13°; -1.11°; -0.99°; -0.97°; -0.81°; -0.71°. The chlorine which had been 10.65 per liter decreases progressively to 9.23; 8.52; 7.81; 7.10; 6.74; 6.39; 4.26. With a 29.35‰ solution, the evacuation takes even longer; the Δ decreases progressively from -1.9° to -0.74° at the end of 55 min; the proportion of chlorine per liter drops from 15.08 to 5.68. With a 33.65‰ /176 solution, the Δ decreases first rapidly from -2.24° to -1.5° and then successively and slowly to -0.95°. A comparison of the concentration of gastric juice and duodenal juice will show a considerable difference, with the Δ after 20 min being equal to -1.9° in the stomach and to -1.44° in the duodenum; the proportion of chlorine per liter is 17.57 in the stomach and only 12.60 in the duodenum. With a 38‰ solution, the pyloric evacuation is very slow; an abundant secretion is produced and the Δ which had been -2.47° changes progressively to -0.77° while the chlorine drops from 23‰ to 5.14.

Finally, with a 77‰ solution, the evacuation becomes still slower; an abundant secretion of mucus takes place: The Δ decreases progressively from -4.8° to -0.73°, while the chlorine drops from 46.46 to 7.10 per liter.

In summation, the more strongly hypertonic the absorbed solution is the more will its pyloric evacuation be retarded: Molecular equilibrium with the body fluids is established partly in the stomach and partly in the duodenum; this equilibrium apparently is approached much more rapidly than in the case of hypotonic solutions. The mechanism by which this equilibrium is established is highly complex; the dilution of the liquid by gastric and duodenal secretions is not the only responsible factor since, in some cases, such a dilution would require a secretion of more than 2 ltr of liquid. On the other hand, one must consider the fixation of NaCl by the mucous membranes and by the mucus as well as the parallel depletion of the solution. These hypotheses will be discussed further in a later paper.

As to the differences in the functioning of the pylorus, which follow the osmotic pressure of the solutions, they most likely are due to a reflex whose origin is in the duodenal wall which latter is differently affected by solutions of differing molecular concentration. In fact, we found that, even after gastric ingestion of an isotonic solution, the gastric evacuation could be retarded and closing of the pylorus could be obtained by simultaneously injecting a few drops of a strongly hypertonic solution into the duodenum.

This opening and closing reflex of the pylorus, in accordance with the molecular concentration, obviously has the function of regulating the course of gastric evacuation and by this very effect controls the process that tends to establish isotony of the ingested liquids before their passage into the circulating blood.

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